

Amendments to the Claims

The following listing of claims will replace all prior versions and/or listings of claims in the application.

Listing of Claims:

1-530. (cancelled)

531. (previously presented): A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from heaters to at least a section of the formation;

allowing the heat to transfer from the heaters to a part of the formation, wherein superposition of heat from at least two of the heaters pyrolyzes at least some hydrocarbons in the part of the formation;

controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure, and wherein the controlled pressure is at least about 2.0 bars absolute; and

producing a mixture from the formation.

532. (cancelled)

533. (previously presented): The method of claim 531, further comprising controlling formation conditions, wherein controlling formation conditions comprises maintaining a temperature in the part of the formation in a pyrolysis temperature range from about 270 °C to about 400 °C.

534. (previously presented): The method of claim 531, wherein at least one of the heaters comprises an electrical heater.

535. (withdrawn): The method of claim 531, wherein at least one of the heaters comprises a surface burner.

536. (withdrawn): The method of claim 531, wherein at least one of the heaters comprises a flameless distributed combustor.

537. (previously presented): The method of claim 531, wherein at least one of the heaters comprises a natural distributed combustor.

538. (cancelled)

539. (previously presented): The method of claim 531, wherein providing heat from the heaters to at least the section of the formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h*V*C_v*\rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day.

540. (cancelled)

541. (previously presented): The method of claim 531, wherein allowing heat to transfer from the heaters increases a thermal conductivity of at least some of the part of the formation to greater than about 0.5 W/(m °C).

542. (original): The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

543. (original): The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

544. (original): The method of claim 531, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

545. (original): The method of claim 531, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

546. (original): The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

547. (original): The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

548. (original): The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

549. (original): The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

550. (original): The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

551. (original): The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

552. (original): The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

553. (original): The method of claim 531, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

554. (previously presented): The method of claim 531, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

555. (original): The method of claim 531, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

556. (original): The method of claim 531, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

557. (cancelled)

558. (previously presented): The method of claim 531, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ in the mixture is greater than about 0.5 bar.

559. (cancelled)

560. (previously presented): The method of claim 531, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

561. (cancelled)

562. (cancelled)

563. (previously presented): The method of claim 531, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, and hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

564. (previously presented): The method of claim 531, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

565. (previously presented): The method of claim 531, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that a permeability of the majority of the part of the formation is substantially uniform.

566. (original): The method of claim 531, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

567. (previously presented): The method of claim 531, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

568. (previously presented): The method of claim 531, further comprising providing heat from heaters to at least some of the formation, wherein the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

569. (previously presented): The method of claim 531, further comprising providing heat from heaters to at least some of the formation, wherein the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

570. (previously presented): A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heaters to at least a section of the formation;

allowing the heat to transfer from the one or more heaters to a part of the formation to raise an average temperature in the part of the formation to, or above, a temperature that will pyrolyze hydrocarbons in the part of the formation;

producing a mixture from the formation; and

controlling API gravity of the produced mixture to be greater than about 25 degrees API by controlling average pressure and average temperature in the part of the formation such that the average pressure in the part of the formation is greater than the pressure (p) set forth in the following equation for an assessed average temperature (T) in the part of the formation:

$$p = e^{[-44000/T + 67]}$$

where p is measured in psia and T is measured in Kelvin.

571. (original): The method of claim 570, wherein the API gravity of the produced mixture is controlled to be greater than about 30 degrees API, and wherein the equation is:

$$p = e [-31000/T + 51].$$

572. (original): The method of claim 570, wherein the API gravity of the produced mixture is controlled to be greater than about 35 degrees API, and wherein the equation is:

$$p = e [-22000/T + 38].$$

573. (previously presented): The method of claim 570, wherein the one or more heaters comprise at least two heaters, and wherein superposition of heat from at least the two heaters pyrolyzes at least some hydrocarbons in the part of the formation.

574. (previously presented): The method of claim 570, wherein controlling the average temperature comprises maintaining a temperature in the part of the formation in a pyrolysis temperature range from about 270 °C to about 400 °C.

575. (previously presented): The method of claim 570, wherein at least one of the heaters comprises an electrical heater.

576. (withdrawn): The method of claim 570, wherein at least one of the heaters comprises a surface burner.

577. (withdrawn): The method of claim 570, wherein at least one of the heaters comprises a flameless distributed combustor.

578. (previously presented): The method of claim 570, wherein at least one of the heaters comprises a natural distributed combustor.

579. (previously presented): The method of claim 570, further comprising controlling a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

580. (previously presented): The method of claim 570, further comprising controlling the heat such that an average heating rate of the part of the formation is less than about 1 °C per day in a pyrolysis temperature range from about 270 °C to about 400 °C.

581. (previously presented): The method of claim 570, wherein providing heat from the one or more heaters to at least the section of the formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h*V*C_v*\rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day.

582. (original): The method of claim 570, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

583. (previously presented): The method of claim 570, wherein providing heat from the one or more heaters increases a thermal conductivity of at least some of the part of the formation to greater than about 0.5 W/(m °C).

584. (original): The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

585. (original): The method of claim 570, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

586. (original): The method of claim 570, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

587. (original): The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

588. (original): The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

589. (original): The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

590. (original): The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

591. (original): The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

592. (original): The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

593. (original): The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

594. (original): The method of claim 570, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

595. (previously presented): The method of claim 570, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

596. (original): The method of claim 570, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

597. (original): The method of claim 570, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

598. (previously presented): The method of claim 570, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ in the mixture is greater than about 0.5 bar.

599. (previously presented): The method of claim 570, wherein a partial pressure of H₂ is measured when the mixture is at a production well.

600. (previously presented): The method of claim 570, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

601. (previously presented): The method of claim 570, further comprising recirculating a portion of hydrogen from the mixture into the formation.

602. (previously presented): The method of claim 570, further comprising:
providing hydrogen (H_2) to the part of the formation to hydrogenate hydrocarbons in the part of the formation; and
heating at least some of the part of the formation with heat from hydrogenation.

603. (previously presented): The method of claim 570, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, and hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

604. (previously presented): The method of claim 570, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

605. (previously presented): The method of claim 570, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that the permeability of the majority of the part of the formation is substantially uniform.

606. (original): The method of claim 570, wherein the heat is controlled to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

607. (previously presented): The method of claim 570, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

608. (previously presented): The method of claim 570, further comprising providing heat from heaters to at least some of the formation, wherein the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

609. (previously presented): The method of claim 570, further comprising providing heat from heaters to at least some of the formation, wherein the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

610-5395. (cancelled)

5396. (previously presented): The method of claim 567, wherein at least about 20 heaters are disposed in the formation for each production well.

5397. (previously presented): The method of claim 607, wherein at least about 20 heaters are disposed in the formation for each production well.

5398. (cancelled)

5399. (cancelled)

5400. (previously presented): The method of claim 531, further comprising providing H₂ to at least some of the formation.

5401. (previously presented): The method of claim 531, further comprising providing H₂ to at least some of the formation to hydrogenate hydrocarbons in the formation.

5402. (previously presented): The method of claim 570, further comprising providing H₂ to at least some of the formation.

5403. (previously presented): The method of claim 570, further comprising providing H₂ to at least some of the formation to hydrogenate hydrocarbons in the formation.

5404-5440. (cancelled)

5441-5528. (not entered)

5529. (previously presented): A method of treating a hydrocarbon containing formation in situ, comprising:

- providing heat from one or more heaters to at least a section of the formation;
- allowing the heat to transfer from the one or more heaters to a part of the formation;
- controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure, wherein the controlled pressure is at least about 2.0 bars absolute, wherein an average heating rate of the part of the formation is less than about 1 °C per day in a pyrolysis temperature range, and wherein the pyrolysis temperature range is from about 270 °C to about 400 °C; and
- producing a mixture from the formation.

5530. (previously presented): The method of claim 5529, further comprising controlling formation conditions, wherein controlling formation conditions comprises maintaining a temperature in the part of the formation in the pyrolysis temperature range, wherein the pyrolysis temperature range is from about 270 °C to about 400 °C.

5531. (previously presented): The method of claim 5529, wherein at least one of the heaters comprises a natural distributed combustor.

5532. (currently amended): The method of claim 5529, wherein providing heat from the one or more heaters to at least the section of the formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (P_{wr}) provided to the selected volume is equal to or less than $h \cdot V \cdot C_v \cdot \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about ~~10 °C/day~~ 1 °C/day.

5533. (previously presented): The method of claim 5529, wherein allowing heat to transfer from the one or more heaters increases a thermal conductivity of at least some of the part of the formation to greater than about 0.5 W/(m °C).

5534. (previously presented): The method of claim 5529, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

5535. (previously presented): The method of claim 5529, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

5536. (previously presented): The method of claim 5529, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

5537. (previously presented): The method of claim 5529, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5538. (previously presented): The method of claim 5529, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

5539. (previously presented): The method of claim 5529, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

5540. (previously presented): The method of claim 5529, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5541. (previously presented): The method of claim 5529, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

5542. (previously presented): The method of claim 5529, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

5543. (previously presented): The method of claim 5529, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

5544. (previously presented): The method of claim 5529, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5545. (previously presented): The method of claim 5529, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

5546. (previously presented): The method of claim 5529, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

5547. (previously presented): The method of claim 5529, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

5548. (previously presented): The method of claim 5529, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

5549. (previously presented): A method of treating a hydrocarbon containing formation in situ, comprising:

- providing heat from one or more heaters to at least a section of the formation;

- allowing the heat to transfer substantially by conduction from the one or more heaters to a part of the formation;

- controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure, and wherein the controlled pressure is at least about 2.0 bars absolute; and

- producing a mixture from the formation.

5550. (previously presented): The method of claim 5549, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ in the mixture is greater than about 0.5 bar.

5551. (previously presented): The method of claim 5549, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5552. (previously presented): The method of claim 5549, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, and hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

5553. (previously presented): The method of claim 5549, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

5554. (previously presented): The method of claim 5549, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that a permeability of the majority of the part of the formation is substantially uniform.

5555. (previously presented): The method of claim 5549, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

5556. (previously presented): The method of claim 5549, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

5557. (previously presented): The method of claim 5549, further comprising providing heat from heaters to at least some of the formation, wherein the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

5558. (previously presented): The method of claim 5549, further comprising providing heat from heaters to at least some of the formation, wherein the heaters are located in the formation in

a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

5559. (previously presented): A method of treating a hydrocarbon containing formation in situ, comprising:

- providing heat from one or more heaters to at least a section of the formation;
- allowing the heat to transfer from the one or more heaters to a part of the formation;
- controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure, and wherein the controlled pressure is at least about 2.0 bars absolute;
- producing a mixture from the formation; and
- wherein the mixture comprises H_2 , and wherein the partial pressure of the H_2 is measured when the mixture is at a production well.

5560. (previously presented): The method of claim 5559, further comprising controlling formation conditions, wherein controlling formation conditions comprises maintaining a temperature in the part of the formation in a pyrolysis temperature range, and wherein the pyrolysis temperature range is from about 270 °C to about 400 °C.

5561. (previously presented): The method of claim 5559, wherein at least one of the heaters comprises a natural distributed combustor.

5562. (previously presented): The method of claim 5559, wherein providing heat from the one or more heaters to at least the section of the formation comprises:

- heating a selected volume (V) of the hydrocarbon containing formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h*V*C_v*\rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day.

5563. (previously presented): The method of claim 5559, wherein allowing heat to transfer from the one or more heaters increases a thermal conductivity of at least some of the part of the formation to greater than about 0.5 W/(m °C).

5564. (previously presented): The method of claim 5559, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

5565. (previously presented): The method of claim 5559, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

5566. (previously presented): The method of claim 5559, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

5567. (previously presented): The method of claim 5559, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5568. (previously presented): The method of claim 5559, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

5569. (previously presented): The method of claim 5559, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

5570. (previously presented): The method of claim 5559, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5571. (previously presented): The method of claim 5559, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

5572. (previously presented): The method of claim 5559, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

5573. (previously presented): The method of claim 5559, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

5574. (previously presented): The method of claim 5559, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5575. (previously presented): The method of claim 5559, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

5576. (previously presented): The method of claim 5559, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the

molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

5577. (previously presented): The method of claim 5559, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

5578. (previously presented): The method of claim 5559, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

5579. (previously presented): A method of treating a hydrocarbon containing formation in situ, comprising:

- providing heat from one or more heaters to at least some of the formation;
- allowing the heat to transfer from the one or more heaters to a part of the formation;
- controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure, and wherein the controlled pressure is at least about 2.0 bars absolute;
- producing a mixture comprising molecular hydrogen from the formation; and
- recirculating a portion of the molecular hydrogen from the mixture into the formation.

5580. (previously presented): The method of claim 5579 further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ in the mixture is greater than about 0.5 bar.

5581. (previously presented): The method of claim 5579, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5582. (previously presented): The method of claim 5579, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, and hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

5583. (previously presented): The method of claim 5579, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

5584. (previously presented): The method of claim 5579, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that a permeability of the majority of the part of the formation is substantially uniform.

5585. (previously presented): The method of claim 5579, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

5586. (previously presented): The method of claim 5579, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

5587. (previously presented): The method of claim 5579, further comprising providing heat from heaters to at least some of the formation, wherein the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

5588. (previously presented): The method of claim 5579, further comprising providing heat from heaters to at least some of the formation, wherein the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

5589. (previously presented): A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heaters to at least a section of the formation;

allowing the heat to transfer from the one or more heaters to a part of the formation;

controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure, and wherein the controlled pressure is at least about 2.0 bars absolute;

providing hydrogen (H_2) to the part of the formation to hydrogenate hydrocarbons in the part of the formation;

heating at least some of the part of the formation with heat from hydrogenation; and

producing a mixture from the formation.

5590. (previously presented): The method of claim 5589, further comprising controlling formation conditions, wherein controlling formation conditions comprises maintaining a temperature in the part of the formation in a pyrolysis temperature range, wherein the pyrolysis temperature range is from about 270 °C to about 400 °C.

5591. (previously presented): The method of claim 5589, wherein at least one of the heaters comprises a natural distributed combustor.

5592. (previously presented): The method of claim 5589, wherein providing heat from the one or more heaters to at least the section of the formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from the one or more heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h*V*C_v*\rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day.

5593. (previously presented): The method of claim 5589, wherein allowing heat to transfer from the one or more heaters increases a thermal conductivity of at least some of the part of the

formation to greater than about 0.5 W/(m °C).

5594. (previously presented): The method of claim 5589, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

5595. (previously presented): The method of claim 5589, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

5596. (previously presented): The method of claim 5589, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the non-condensable hydrocarbons are olefins.

5597. (previously presented): The method of claim 5589, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

5598. (previously presented): The method of claim 5589, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

5599. (previously presented): The method of claim 5589, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

5600. (previously presented): The method of claim 5589, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

5601. (previously presented): The method of claim 5589, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

5602. (previously presented): The method of claim 5589, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

5603. (previously presented): The method of claim 5589, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

5604. (previously presented): The method of claim 5589, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

5605. (previously presented): The method of claim 5589, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

5606. (previously presented): The method of claim 5589, wherein the produced mixture comprises a non-condensable component, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

5607. (previously presented): The method of claim 5589, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

5608. (previously presented): The method of claim 5589, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

5609. (previously presented): The method of claim 5589, further comprising controlling formation conditions to produce a mixture of condensable hydrocarbons and H₂, wherein a partial pressure of H₂ in the mixture is greater than about 0.5 bar.

5610. (previously presented): The method of claim 5589, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5611. (previously presented): The method of claim 5589, wherein the produced mixture comprises hydrogen and condensable hydrocarbons, and hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

5612. (previously presented): The method of claim 5589, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 100 millidarcy.

5613. (previously presented): The method of claim 5589, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that a permeability of the majority of the part of the formation is substantially uniform.

5614. (previously presented): The method of claim 5589, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

5615. (previously presented): The method of claim 5589, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

5616. (previously presented): The method of claim 5589, further comprising providing heat from heaters to at least some of the formation, wherein the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.